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OF WHAT USE IS DIMENSIONAL SOCIOLOGY?

A Report of Further Research upon the Utility, Precision and Parsimony of Dimensional Analysis

BY

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I. THE ISSUE OF UTILITY

IN REVIEWING the author's study *Dimensions of Society* Mr. Donald W. Calhoun asks, "Now what practical value does the S-theory possess?"[1]

The new methodological S-system seems to the author to have five chief uses: A) for calculating sociological unknowns, both quantitative and qualitative; B) for proving sociological theorems and corollaries; C) for checking the formulation of sociological problems; D) for operationally defining reliable concepts; E) for systematizing fields of science. The first three uses have developed since the book went to press four years ago and so are new evidence not available to the reviewer.

A. Calculation of sociological unknowns. Mr. Calhoun notes that S-equations were asserted to be usable for description only and not for calculating unknowns. Further research has proved this assertion of mine to have been over-cautious and untrue. *For S-equations can calculate unknowns fully as well as other equations in mathematics* (when properly manipulated according to their rules). Three considerations support this statement in italics.

1. One consideration is that S-notation includes all calculations of mathematics. The semi-colon symbol (;) and the index (I) in S-notation can represent any mathematical operator or variable respectively, so that any calculation of mathematics, including statistics, is possible in S-notation.

2. But is the converse true, i.e., do all S-equations lend themselves to calculation? For the system introduces new symbols not found in mathematics, such as the colon (:) denoting correspondence. Uncertainty on this unexplored question led the author to limit S-equations to descriptive use. Since then, however, syntactic rules have been developed for the new symbols, permitting calculative deductions. It was discovered that when the colon signs connected aggregations of entities (denoted by the scripts, ${}^{s}_{s}|_{s}$, other than the exponent, $|^{s}$,) this became matrix algebra. This branch of algebra, which is being fruitfully applied to human data in such journals as *Psychometrika*, deals with *regular* aggregations in which entities are tabulated rectangularly in rows and columns. The S-notation then develops, in part, matrix algebra. But it is more, for it includes irregular, i.e. non-rectangular matrices, and also qualitative entities (I°) not handled in mathematics hitherto.

3. A third consideration showing that the S-system solves for unknowns consists in its equations of the "qualitative proportions" type. One of these will be illustrated here, somewhat over-simplified in order to avoid taking the reader on too strenuous an excursion into new symbolism. Since it goes beyond current mathematics and logistic also in solving for a qualitative unknown, it may challenge those critics who are convinced that qualitative phenomena in sociology must be, or at least at present are, beyond mathematical treatment.[2]

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[1] The term "S-system" is recommended to replace "S-theory" as the latter has misled many sociologists into expecting a theory predicting social phenomena instead of a methodological theory in being a system of hypotheses for improved methodology.

Since at present the S-system is the only system of symbols in the field of dimensional sociology, the two may be used almost synonymously, but they are not identical. A dimension is an amount of some kind of thing, a distance in some direction, geometrically, a quantity of some quality. Dimensional sociology is any quantitative statement of sociological data which treats all their qualitative aspects with equal rigor.

Mr. Calhoun's review appeared in "Social Forces" for May 1942. The present paper is limited to the issues he raises and omits discussion of other issues such as the inclusiveness, consistancy, reliability, etc., of the new dimensional symbolism.

[2] Bogardus in reviewing *Dimensions of Society* in *Sociology and Social Research* for Sept.–Oct. 1942 stresses this doubt. Our reply in part, is that quantitative treatment of qualitative data requires appropriate techniques which have been largely lacking

To focus thinking, consider an item from a pictorial intelligence test of the "analogies" type. This item presents a problem in non-verbal symbols as: "a Pueblo woman baking bread is to a white housewife ironing as a Pueblo boy dancing is to X," and presents four choices for the solution. This happens to be a picture of a white boy playing baseball. From the data *recorded* in the sentence in quotes above an S-formula can be written. Letting the class scripts indicate their indicators:

Pueblo $= B^\circ$ Female $= F^\circ$
White $= H^\circ$ Male $= M^\circ$
Working $= (W^\circ T^{-1})$
Playing $= (Y^\circ T^{-1})$

Then the problem is formally set up as a proportion as follows:

$$\frac{B^\circ F^\circ(W^\circ T^{-1})}{H^\circ F^\circ(W^\circ T^{-1})} = \frac{B^\circ M^\circ(Y^\circ T^{-1})}{X^\circ} \qquad \text{(Eq. 1a)}$$

To solve for the unknown, X°, cancel out the identity elements (which are unit factors such as F°/F°) in the lefthand ratio and divide through by B° to eliminate this factor from both sides. This yields:

$$\frac{1}{H^\circ} = \frac{M^\circ(Y^\circ T^{-1})}{X^\circ} \qquad \text{(Eq. 1b)}$$

Then multiply both sides by each denominator and cancel out the identity elements, H°/H° and X°/X°, getting the desired solution:

$$X^\circ = H^\circ M^\circ\ (Y^\circ T^{-1}) \qquad \text{(Eq. 1c)}$$

This states that the desired unknown, X°, is the class of "White males playing" and the picture which best represents a member of this class is the correct answer in the intelligence test. Note that by means of the new notation of the zero exponent denoting a quality (i.e. a class, or kind of thing) the equation was solved by the usual mathematical operations hitherto thought applicable only to quantities. Also, note that the first step above in writing the S-equations was not someone's general memories about a Pueblo woman, etc., but was a specific record as given in the sentence in quotes. Such a record is the essential datum for beginning to write an S-equation.

Obviously, in this simple example an intelligent person may get the answer more or less intuitively just as he could similarly solve the quantitative proportion, 1 is to 2 as 3 is to X, and decide that X equals 6, without recourse to the formal symbols and operations of algebra. But just as such recourse is essential when the quantitative proportion is more complex, say $1946/278 = 7943/X$, so the formally symbolized operations become essential to secure a correct answer whenever the qualitative proportion is complex—as it usually is with social data. Thus a sociologist studying social movements may have formulated Abel's hypothesis that: A) widespread discontent; B) a promising ideology; and C) a charismatic leader are among the necessary conditions for D) the success of the movement. A proportioned equation is then set up equating the qualitative ratio $A^\circ B^\circ C^\circ/D^\circ$ to the ratio of an observed instance of these three preconditions to the predicted outcome X°. Any discrepancy between the outcome as predicted by the equation and as eventually observed in society means that the selection, or definition of factors, or of their critical amounts, was faulty. A re-search is then called for, to find neglected qualitative factors, or to re-define the factors, or to insert quantitative coefficients, etc., until predicted and observed outcomes approach agreement. A symbolism is never the substitute for intelligent analysis. But a more adequate symbolism which can treat both quantitative and qualitative data with equal precision and rigor, as S-notation can, should prove a sharpened tool for such analysis.

B. PROVING OF SOCIOLOGICAL THEOREMS AND COROLLARIES. A second use of the S-system is to state and prove theorems and corollaries of sociological content. Within the past year, it has been discovered that the new S-symbols can be exactly translated into the symbols of Logistics, or modern Symbolic Logic. The definitions and laws, the theorems and exercises in Part I of Alfred Tarski's *Introduction to Logic* (Oxford University Press, 1941) were translated into S-notation to test their equivalence.[3] The S-system was found

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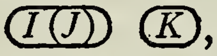
hitherto. The S-system contributes to such techniques. More adequate techniques for quantifying or precisionizing qualitative data may be expected to develop sociology toward becoming an exact science, in which the prediction and control of societal phenomena will be improved.

[3] In a paper entitled "A Parsimonious Symbolism Adapted to the Social Sciences," which is undergoing scrutiny of several logicians, the author presents these equivalences in detail. The chief equivalences are, briefly; that I°, properly scripted, denotes either a

to be entirely integrable with logistics. It is an extension and application of logistics to societal data. It was not rigorously derived deductively from a few primitive terms and postulates as is logistics, since the S-system was induced by trial and error from several thousand sets of societal data.[4] Therefore the S-formulae hitherto published may not conform rigorously in all respects to the rules of Logistics. In the future, however, S-formulae should so conform, and the S-rules in Appendix II of *Dimensions of Society* should be modified wherever necessary. But the significant finding is that since the S-system is a version of Logistics, it can be used to state and prove theorems and corellaries about *recorded* societal data with all the rigor of modern symbolic logic. This application of logic to sociology needs collaborators and time to bear fruit.

A simple illustration of this use of the S-system to aid rigorous reasoning consists in one of the laws of the categorical syllogism. This law is stated by Tarski as that: If the class I includes the class J ($I \supset J$), and if the logical product of the class I and the class K is nul ($I \cap K = \lambda$), and if the class J is not nul ($J = \backsim \lambda$), then the logical product of J and K is nul ($J \cap K = \lambda$). In terms of a circle diagram, , it is obvious that, if the members of J are all members of I none of whose members overlap with K, then no members of J can be members of K.[5] This law can be extended to cover correlations of quantitative variables such as any attitude tests or cultural scales.

This discovery was a deduction from the S-system. It was deduced by shifting the zero exponent to unit exponents and inquiring into the consequences. The consequence was that the logical product with its special subcases of logical inclusion and logical equivalence became correlation coefficients varying from zero to unity. Alternatively stated, the correlation coefficients were found to be the metricized versions of logical products, inclusions, and equivalences.[6] This consequence leads to the extended law, applied to cultural phenomena. It is here stated as a theorem capable of proof. For example:

Theorem I. If the culture complex I and the culture complex K are uncorrelated, and if I is a combination of the culture traits J and other uncorrelated traits M, then it can be predicted (within limits of the standard errors of the correlations when corrected for attenuation, of course) that the culture traits J will be observed to be uncorrelated in that population with the culture complex K.[7]

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logical class or a relation; that S denotes a sentence or sentential function (usually a composite one); that $°I = \sim I$, a class denied or emptied of members; that $V - I° = I'$, the complement of a class; that between qualities, such as $I°$ or $S°$, the plus sign (+) denotes the logical sum of classes and disjunction of sentences, and that juxtaposition denotes the logical product of classes and conjunction of sentences, and that the colon (:) denotes the inclusion of a class and implication of a sentence.

This paper also presents the new contributions of the S-system to logistics in the zero-exponent, colon, descripts, qualitative division and qualitative subtraction, ($I°$,:, ${}^{s}_{s}|_{s}$,/$I°$, $-I°$). These adapt logistics better to societal data. They also tend to unify logistics and mathematics more closely.

[4] Such rigorous deduction of the S-system is in process. One novel feature of it is to start with operationally specified primitive terms rather than with verbally specified primitive terms, i.e. "distinguishable," "time," "space," "people," instead of "class," "member," "neither . . . nor," etc. This derivation may take years to develop unless close cooperation with some symbolic logician can be cultivated in spite of the author's remoteness in Syria.

[5] A statement of this law in current logistic symbols is:

$$[(I \supset J) \wedge (I \cap K = \Lambda) \wedge (J = \sim\Lambda)] \rightarrow [J \cap K = \Lambda] \quad \text{Eq. 2a}$$

and in S-symbols is:

$$S_{JK=0}:S_{KI:J\neq 0} = O \qquad \text{Eq. 2b}$$

The legend verbalizing this S-formula is: The situation where the product of K and J is zero includes the situation where zero is the product of K and I when I has a non-zero subclass J. (The zero exponent on each letter in the S-formula may be omitted as understood in the context of logic where no confusion is likely with the exponent of unity which is understood in a mathematical context.)

Note the relative parsimony of the two formulations in that logistics requires thirty symbols or 100 per cent more than the fifteen symbols required by S-notation.

[6] Details of this transformation from logical product to correlation coefficient may be found in a paper entitled "A Generalization of Statistical and Logistic Formulas" which the author completed before leaving the United States (Oct. 1942). (This paper will presently be available in microfilm at the Library of Congress.)

[7] This theorem is statable in S-notation as:

$$S_{J\cdot K=0}:S_{(I\cdot K=0=J\cdot M)(I=J+M)} \qquad \text{Eq. 2c.}$$

This example is but a minute hint of the uses for proving theorems and corollaries which may open when symbolic logic is applied to societal data as the S-system begins to apply it.

C. Checking sociological formulations. A third use of dimensional sociology is to check the equations which formulate sociological problems, relations, hypotheses, etc. This checking means determining whether the two sides of an equation have the same dimensionality, i.e. have the same sectors and exponents. This is the major use of dimensional analysis in physics, but its use in sociology is as yet largely unexplored. It remains among the research problems suggested in Appendix III of *Dimensions* (p. 918).

An example will clarify this principle of *equivalent dimensionality*. Mr. Calhoun found that the author's "tension equation" was inadequate to predict the course of a lynching. We agree. It was inadequate partly because he applied the wrong formula. Had he followed the semantic rules for writing S-formulae (Rules #16 and #32 in Appendix II of *Dimensions of Society*) he would have found that the dynamic and interacting nature of the lynching situation required T^{-2} and P^2 in its dimensions. Instead of these dimensions, he chose the formula for the static and interactionless case of "simple tension" p. 265, and from this wrong premise draws the correct and expected conclusion that his formula was inadequate. The dimensions of a static and interactionless tension are T^0 and P^1. Since the dimensionalities differed (i.e. $T^{-2} \neq T^0$ and $P^2 \neq P^1$), the formula he chose is proven to be incorrect for formulating that situation.

D. Operational defining of sociological concepts. A fourth use of the S-system is that, as Mr. Calhoun notes, it has already served to define some "three hundred sociological concepts." This number is now more than doubled when to the formulae in "Dimensions of Society" are added the formulae in the Appendices of a new simplified textbook of systematic sociology which is in preparation.

But a qualification should be noted, that these definitions are for the most part *semi-operational* ones. A definition has been defined[8] to be an operational one (a) to the extent that it specifies the procedures and materials used in order to identify or generate the definiendum and (b) to the extent that high reliability is found for this definition. The reliability of the S-system has been measured in one series of experiments (reported in detail in the volume reviewed pp. 65, 66) and found to between 93 percent and 99 percent. But the reliability of most of these concepts separately has not been determined as yet. Each of these semi-operational definitions is a methodological hypothesis to be tested as to reliability, utility, etc., by anyone using it in research. Because the reliability differentia (B) of the definition above has been measured only in part, the S-formulae for individual concepts are mostly semi-operational definitions at present. This prefix "semi-" also denotes that while the S-formula specifies the operations for combining the *recorded* data to get the concept defined, it does not specify the necessary prior operations of getting recorded data from phenomena. Hence it is an incomplete operational definition. But even though the S-concepts have been only partially tested for reliability, it should be noted that this is more than has yet been attempted for any other *system* of concepts in any social science.

One further comment may save operationalism both from overuse by friends and nonuse by opponents. The place of operational definitions in sociology is seen as one means among others to improve *reliability*; reliability is one means among others to improve the observed *correlations* between phenomena, measuring the degree of *prediction and control* that is concurrently possible. Prediction and control are the ends of science, but are in turn a means to trans-scientific ends of improving human *adjustments* in whatever way men desire.

E. Systematizing fields. The fifth use of dimensional analysis is to systematize a field of science. It provides a classification of recorded data in a field. This classification conforms rigorously to the canons of logic in that it is totally inclusive of its field, mutually exclusive in its classes, and subclassifies upon a single basis at each level.

Where the heavy dot ($\cdot$) denotes correlation, and where the colon denotes that the second situation is a sub-situation of the first S, i.e. that the second S implies the first, or "if S_2, then S_1."

[8] See "Operational Definitions Operationally Defined," by the author in the *Amer. Journal of Sociology*, Jan. 1943.

1. The field of general sociology. Mr. Calhoun says in his "evaluation": "Whether or not Dodd's system is parsimonious or otherwise useful, he provides a comprehensive classification of the quantitative data sociologists work with." Progressively, we believe, this restriction to quantitative data can be lifted as the application of the *S*-system to qualitative data becomes more fully worked out. This restriction is a temporary one, owing to the immature state of current research, and is not inherent in the nature of the *S*-system.

The classification of any and all steps of *recorded* societal data, or concepts, or statements of relation among them, into standard pigeonholes, fixed by their quantic numbers (which are the exponents from an *S*-formula) introduces order into the field of sociology to an extent hitherto considered impossible. It is this quantic number that seems to us to provide a comprehensive classification for the recorded data of sociology such as to justify the claim that the *Dimensions of Society "begins* to construct a quantitative systematic science of sociology." With the quantic classification standard filing systems for data, the reliability of which in use by one clerk as against another has been measured and found nearly perfect (97 percent to 99 percent), become possible. With the quantic classification the selection of topics and their sequence in textbooks or courses can consistently follow a rigorously logical principal and not have to be organized, according to Small's wisecrack, on the "omnium gatherum" principle.

2. The field of statistics. The *S*-notation may be used to systematize fields of science even beyond general sociology. An unexpected systematizing in the field of statistics emerged in the summer of 1942 as a by-product when exploring the relative parsimony of dimensional and statistical notations. In this exploration the 434 formulae in Dunlap and Kurtz's *Handbook of Statistical Nomographs, Tables, Formulas* (World Book Company, 1932) were taken as a representative sample of the formulae of all the introductory statistical textbooks and were rewritten in *S*-notation. Upon degenerating the general *S*-formula, namely:

$$S = {}^{s}_{s}(T;I;L;P)^{s}_{s} \qquad \text{(Eq. 3)}$$

to the special case that is a product-moment of two frequency variables, developed by their scripts, the resulting formula proved to be a master formula for all the types of correlation—rectilinear and curvilinear, biserial and fourfold, rank and contingency—and to unify these raw forms of correlation with its compounded forms in sums and differences, in part, partial, multiple and double multiple correlation. This master formula, christened the Z_3 statistic, has basically two variables and ten parameters[9] which specify units, origins, and exponents. As a few of these parameters take varying values while the rest vanish as identity elements, the master formula becomes each special formula in turn.

Furthermore, it was found that this master formula was not limited to correlations; it covers all the measures of central tendency, the measures of dispersion, and all the statistical moments. It even subsumes the formulae of logistics (for the logical product, logical sum, inclusion, equivalence, nul class, universal class, etc.) as special cases when the exponent parameters became zero. In short, of the 434 statistical formulae in this sample, 286, or 66 percent became special cases of the master formula for Z_3. Another 30 percent were found to be functions of it in further combinations. This master formula not only subsumed the bulk of the formulae of elementary statistics as special cases, but arranged them in orderly classes and subclasses according to the values of the parameters. This systematizing of statistics, a field hitherto com-

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[9] The parmeters in an equation contrast with the variables in it in that the parameters are constant in any one application of the equation, but may vary in specified ways between applications making variant subcases of the equation or formula. Thus, in the equation for a "developed variable," Z, namely:

$$Z = (X - O)^E/U \qquad \text{(Eq. 4a)}$$

The X is an undeveloped or raw frequency variable, while the parameters are the origin, O, the unit, U, and the exponent, E. The Z_3 statistic is the developed product-moment of the two developed variables, i.e., if:

$$X_3 = \Sigma\, Z_1\, Z_2/N \qquad \text{(Eq. 4b)}$$

then

$$Z_3 = (X_3 - O_3)^{E_3}/U_3 \qquad \text{(Eq. 4c)}$$

For examples of Z_3 turning into various familiar formulae note that it becomes the arithmetic mean when $E_2 = O$ and the other parameters are identity elements (i.e., the origins are zero and the exponents and units are unities as usual if not specified); while Z_3 becomes the variance when the origin is the mean and $X_1 \equiv X_2$; and it becomes the correlation coefficient when the first two origins are means and the first two units are standard deviations.

posed largely of heterogeneous formulae, each derived for a particular purpose, is a striking use of dimensional analysis. In a further study, still unpublished, statistical data, as contrasted with statistical formulae above, were found to be neatly classifiable in a way which rigorously conformed to the logical canons of classification, as stated above.

3. The field of economics. Dimensional analysis may prove useful for systematizing in the field of economics. An hypothesis was outlined in *Dimensions of Society* (p. 540–3) that all recorded sets of economic data and economic laws could be derived from a matrix equation which is a special case of the general S-formula. If this proves true, all recorded economic data and principles may become systematizable by regularly varying the scripts in this matrix equation. This "exchange matrix hypothesis" seems promising but needs fuller exploration before the validity and significance of this use of the S-system can be appraised.

4. The field of all the sciences. It is possible that S-system may have systematizing implications for all science and not only for the social sciences. This hypothesis has developed largely since the book was sent to press, so that only its implications for physics and for metaphysics were mentioned there (see pp. 123, 200, 826, 917). For metaphysics, Kant's four categories of the understanding and their twelve subcategories are neatly specified by the quantics and descripts of the four sectors of the S-system. For physics, the fundamental dimensional formula into which all other physical formulae are convertible is the special case of the general S-formula, Eq. 3, where the P is zero and the I may represent mass or temperature or charge. The S-notation has been demonstrated to be integrable with mathematics including statistics and with symbolic logic, as mentioned above. In the grammar of prose, the parts of speech seem translatable into S-symbols if one uses: for substantives, indices (I); for verbs, indices with a time factor included (IT^t); for modifiers, scripts, ${}^{s}_{s} \mid {}^{s}_{s}$; and for connectives, operators (;) of various kinds. Chemical equations of the various types have been written in S-notation and found to harmonize easily. Chemical formulae and equations thus become expressible in S-formulae which are compounded of the 90-odd dimensions which are the 90-odd atomic elements (plus isotopes, and attributes denoting the charges of ions, etc.). The possibility of expressing biological data in dimensional terms might be tested on such a book as Woodger's *Axiomatic Method in Biology* (Cambridge Univ. Press, 1937). Similar preliminary exploration for psychology has been started. Just to what extent a dimensional notation and rules for it may develop tending to unify all science, is unknown. This hints at a development which may eventually prove to be a major utility of the S-system.

From a different approach, another use of the S-system towards systematizing all the sciences was discovered when the sectors (T, L, I, P) were plotted in relation to each other. This graph reveals a striking pattern of law and order in the cosmos. Its details and controversial issues are reported elsewhere.[10] The uses of the S-system—to calculate sociological unknowns, to prove sociological theorems, to check sociological formulations, to define concepts more reliably, and to systematize fields—are believed to be only a sample of the usefulness of an improved symbolism in sociology. These are some of the first fruits forecast in "Dimensions of Society" (p. 63). The development of these and other uses will depend, of course, on the extent to which sociologists learn the symbolism and apply it creatively to their problems.

II. THE PRECISION ISSUE

Mr. Calhoun raises the issue: "the question is left in the reader's mind: if the S-theory...falls short of the precision and adequacy of ordinary statistics, then what case can be made for the expenditure of time and effort necessary to master the new language of symbols....?" Apparently the present author failed to make clear that S-formulae are *more* precise than current statistical formulae in at least four respects. This greater precision is due to the scripts and colon symbol. It may be summarized under the four headings of precisionizing quantities, making qualities explicit, precisionizing qualities, and specifying limits.

A. PRECISIONIZING QUANTITIES. In the first place, S-formulae are more precise than statistical formulae in that the former specify explicitly the *degree of precision* of the variables in the formulae. Beginning with the zero exponent and an identifying class-script, X°_{1}, a quality, a logical class, is symbolized. "A quality" here means "difference of kind," "any distinguishable entity," and not necessarily a value judgment. X is here identical with the index (I), of S-notation. On noting the presence or absence of this quality in a given situation, it becomes primitively quantified into an all-or-none variable and may be assigned numerical values of 1 and 0 and symbolized by the case script as ${}^{1,\circ}X$. If more precisely observed in ordinal degree (such as "none," "some," "more," "most"), it is symbolized by more points in the case script without connotation of equal intervals between them, as ${}^{x}X$. If still more precisely observed as a multiple of a standard unit, it becomes a cardinal number or series, symbolized by the class-interval script which denotes equal units, as ${}_{x}X$. Conventional Statistics has no notation to specify these four degrees of precision from purely qualitative data or attributes to fully quantified data. This often leads into inaccuracies as a result, as when a person unnecessarily uses ordinal data (ranks) in formulae designed for cardinals or vice versa. Also Statistics have had to develop special formulae for attributes, whereas the S-notation for them, ${}^{1,\circ}X$, makes them the limiting two-valued case of any multi-valued variable and automatically extends all formulae to cover them (with the entailed greater need, of course, for such corrections for broad intervals as those of Shepard).

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[10] In a paper by the author entitled "A Mass-time Triangle, a Diagram of man in space and time", which has been circulated for critical revision among scientists of all fields and will appear soon in *Philosophy of Science*.

This series of increasing precision seems to the author one solution of the problem of quantifying. For any and every quality can be observed as present or absent, even if techniques for more precise observing have not been developed for it as yet. Quantifying is not inherent in the data, but, as Lundberg has emphasized, it consists in an observer's response to the data. This response is most primitive in merely observing whether a distinguishable entity exists or does not exist in a given situation as recorded. This is but a first step, of course, towards greater precision in observing.

B. Making qualities explicit. In the second place, S-notation can explicitly preserve and manipulate the qualitative aspects of any societal data or formula. By means of attribute factors, I°, subclassified as finely as needed, any quantitative formula can be modified or qualified to include explicit statements of its qualitative aspects. S-notation provides *qualifiers* for mathematical formulae, much as adjectives and adverbs qualify nouns and verbs. Furthermore, the zero exponent notation enables calculating with these qualitative factors, both separately and/or in combination with quantitative factors, by the same set of rules as are used for quantitative operations. A simple example is to include quantities in the qualitative proportion, Eq. 1 above. Thus six Pueblo women baking bread are to ten white housewives ironing as eighteen Pueblo boys dancing are to X^1X°. The same operations as used before give the combined quantitative and qualitative solution as "thirty white males playing." Algebra could solve the quantitative proportion only and find the "thirty," but would neglect the qualitative aspects, namely thirty "of what." This neglect makes many critics rightly feel that "quantifying" omits vital elements of description and even denatures the data. But the S-system meets this objection by supplying notation and rules for preserving any manipulating both qualitative and quantitative aspects with equal rigor. Any qualitative nuance can be included and manipulated in an S-formula, provided it can be recorded in words or any other form of record.

One corollary of this principle is that the assumptions and conditions under which a formula holds can be written in the S-notation explicitly in the formula itself. Thus in biserial r the dichotomized variable is assumed to be normally distributed. To denote this fact the equation of the normal distribution curve can be enclosed in parenthesis with a zero exponent outside of it, thus reducing it to the logical class or kind of thing, "normally distributed." This has a numerical value of one (as has every base whose exponent is zero) and so does not affect the numerical value of the biserial r, when this parenthesis is introduced as a factor into the biserial r formula. But qualitatively, it states explicitly that the dichotomized variable is normally distributed. Sociologists sometimes use formulae without regard to their limiting assumptions. S-notation can enforce more precise use of the right formula in the right situation by more explicit specifying of the proper conditions than can be specified by current statistical notation.

A further example of incorporating the conditions under which a formula is to be used in the formula itself is the tension equation. This is that $E = PD/V$, where E is the indicator of tension which is defined by the right hand member of the equation, and where D is the average intensity of desire by a population, P in number, for the available amount of the desideratum, V. A hitherto unpublished correction in this formula is the rule that V must have the same sign for its exponent and its class script. Thus if A is a sign factor ($A = \pm 1$) the revised equation reads:

$$E = PD/V_A^A \qquad \text{(Eq. 6)}$$

Thus, for a negative desideratum, V_-, such as a disease or danger, or other disaster, or probability of it, the negative exponent on V brings V up into the numerator, so that $E = PDV$. This denotes that the (negative) tension varies *directly* with the negative desideratum, whereas (positive) tension varies inversely with a positive desideratum. A negative tension ($-E$) in a population may grow either as the amount of the negative desideratum ($^+V_-$) grows, or as the average intensity of aversion ($-D$) to it increases, or as the number of people (P) who are averse to it increases. So in Mr. Calhoun's illustration of a lynching, his definition of the desideratum, D, as "ease of lynching" needs more exact analysis. Does it mean the probability of consequences undesired by the lynchers—which would be a negative desideratum or does it mean availability of victims to lynch—which would be a positive desideratum to the lynchers? Thus, suppose "ease of lynching" were defined and measured by the number of victims available out of a known group which had aroused the lynchers' resentment. Suppose the situation further was that it had been rumored that only one of the victims was around and that the lynchers' intention was to make an example of one person, not to exterminate the group. Then if the news goes around that several victims are within reach, the positive desideratum is increased. This reduces the tension among the lynchers according to Eq. 6. Reduced tension indicates less effort needed to lynch one victim. But if "ease of lynching" were defined and measured as the lynchers' estimates (at each of various hours) of the probability of undesired consequences being visited upon them, this negative tension, V_{-B} would decrease if that probability decreases, such as by hearing that the sheriff, who was known to be against lynching, was out of town. Since this secondary and negative tension, $-E_B$, (fearing punishment) reduces the primary and positive tension, E_A, (determination to lynch), decrease in the former increases the latter, i.e. as E_B decreases, the algebraic sum of the two tensions ($E_A - E_B$) increases. Each of these various conditions can be specified by an attribute, $I°$, and included as a qualitative factor in the tension equation. All this shows the need of careful defining of terms and attendant conditions in applying the tension formula and recognizing that more than one tension may be involved in the situation (see p. 273, 4).

C. Precisionizing qualities. In the third place, S-notation provides for precise qualitative distinguishing, to any desired degree of fineness. Its scripts provide for subclassifying to any number of levels as symbolized by $I^\circ_{i:j:k:\ldots:z}$. Statistical formulae make no provision of this kind. The ordinary logistic notation can handle a class which includes a subclass which includes a sub-subclass, etc. but becomes clumsy for whole aggregates of classes at each level. S-notation provides for this qualitative distinguishing, for aggregates or for single entities equally well, to any number, z, of levels. This z is the qualitative equivalent of the number of decimal places which specify the degree of precision of a quantitative calculation. This subclassification script may even be thought of as qualitative decimaling. It is a non-quantitative form of precisionizing qualitative data. This provision for subclassifying in the S-system should dispel a frequent objection by those who have seen only summaries of the S-system and have the notion that the four sectors (of time, space, people, and characteristics) are considered an adequate classification for all societal data. These sectors are but the first level of indefinitely many sublevels of classification (some of which are developed in detail in *Dimensions of Society* as in Chapters III and X).

D. Specifying limits and standards. In the fourth place, the S-notation increases the precision of statistical and of logistic formulae in specifying the *limits* within which a formula holds. Thus the case script, $^{A,Z}|$, denotes, if on a time dimension, the beginning and end of the period described, or, if on the indicatory dimension, the lowest and highest points of the scale that are represented in the data. This specification of the limits within which societal data and relations have been observed and hold is important. Its neglect of ten leads to unwarranted generalizations and false conclusions. The case script serves as a "quantifier" serves in Logistics, but goes beyond the logistic limiting of variables in amount as "some" or "all" or "exactly x in number" to limit their range as well.

Specifying these degrees of precision answers in part the objection that social phenomena cannot be quantified because they are "incommensurable." But incommensurability seems a matter of degree of precision. It depends upon the standard of precision used. Thus pi (π) is incommensurable if one takes an absolute standard because its value goes on to more and more decimal places indefinitely. But by a stated standard, whether of five decimal places or fifty, it is commensurable *to that degree of precision.* Similarly, social phenomena are far from being perfectly measurable, but can always be observed at least as present or absent and yielding percentages and probabilities; or often observed more precisely as ordinals and yielding ranks and percentiles; or sometimes observed still more precisely as a cardinal multiple of a standard unit with the calibration of that unit specified. The class-interval script can specify the unit used as the standard. Thus it seems superficial methodology to assert sweepingly that social phenomena either are, or are not, commensurable. The proper procedure is to determine in every given set of data to what degree those data are commensurable by specifying the standard of reference that is used.

III. THE PARSIMONY ISSUE

In Mr. Calhoun's comment above he implies that the time and effort to learn the new symbolism merely adds to the total of current symbolism without a resulting reduction of it. This and other comments indirectly raise the issue of parsimony. Will dimensional analysis economize symbolism in sociology? This question can only be answered by comparing the dimensional symbolism with other symbolisms such as the symbols of statistics, of logistics, or of current verbal descriptions. Three studies have been made trying out each of these three comparisons, and attempting to substitute fact for opinion as arbiters of the issue. These comparisons in respect to parsimony with statistical symbolism and with symbolic logic were made in the summer of 1942 and hence present new evidence which was not available to reviewers of *Dimensions of Society.*

A. THE S-SYMBOLS. Before reporting these researches, a paragraph outlining the number of symbols used in dimensional analysis may be helpful to the reader who has little familiarity with it. The S-system depends on sixteen symbols for all the inductive and deductive manipulation of the *records* which are the data for dimensional analysis. These symbols are 1) the four types of dimensions (T, L, P, I, for time, length of space, people, and indicators of characteristics); 2) the four scripts denoted by their *positions* at the four corners of their base letter ($|^{s}$ the exponent, $|_{s}$ the class script, ${}_{s}|$ the class-interval script, ${}^{s}|$ the case script); 3) the five conventional operators or connectives of mathematics ($+ \; - \; . \; / \; =$, for adding, subtracting, multiplying, dividing, and equating); and 4) three new operators ($: \; \bullet \; '$, for correspondence, correlation, and for identifying a singular entity, respectively). Of these sixteen symbols only four are wholly new: the I to indicate any characteristic (defined[11] as any datum that is not time, space, or people), the case script, the class-interval script, and the colon. All the other twelve symbols are in current use in some field of science of mathematics and have only been extended in meaning by applying them to sociological data.[12] A few additional symbols conveniently represent combinations of the above. Thus (I) an index, or the conventional X, represents T, I, L, or P, or calculated combination of them; and the semi-colon (;), as in Eq. 3, represents any one of the operators. Moreover, all symbols of the S-system can be typed by an ordinary standard typewriter—which is a convenient bit of parsimony in writing and publishing.

B. EXPERIMENTAL COMPARISON WITH THE SYMBOLS OF LOGISTICS. To compare the parsimony of conventional symbols with those of symbolic logic a formal test was to take Tarski's statement of eighteen of the laws of sentential calculus as a sample and count the number of symbols he required. These laws have parallel laws in most cases in the calculus of classes and of relations, so that they may be considered a fair sample of elementary logistics. The finding was that symbolic logic requires 250 symbols to state its laws, whereas S-formulae required only 152. Thus symbolic logic requires 65 percent more symbolism to state its own essence than is required by dimensional formulae. For an example of this greater parsimony in dimensional formulae the reader may turn back to Eq. 2a compared with its restatement in one-half as many S-symbols in Eq. 2b above. To be sure, this greater parsimony of dimensional notation was found from a sample only, but the technique is hereby presented so that others can test it further. The economy is due to giving meaning to the *position* of symbols as where juxtaposition of the two entities denotes multiplication and the four corners of a base letter denote the four scripts.

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[11] In connection with this definition a frequent misunderstanding is that the I's are *merely* a residual category with no homogeneity. This definition is in residual terms in order to guarantee a perfectly inclusive classification but "characteristics" are not merely a residuum. They all have three important properties in common. They can be observed qualitatively, or also quantitatively, or also correlatively i.e. as correlated in patterns. These properties are operationally defined by the exponents of 0.1, and 2 on I's. As these exponents parallel similar quantic subclasses in the other three sectors, I is shown to be a category coordinate with them and not a mere catch-all of odds and ends.

[12] Thus T and L are standardized in dimensional analysis in physics. P is used in population studies. The exponent and the five mathematical operators are standardized in mathematics. The class scrips, $|_{s}$, is used throughout statistics to identify variables. The heavy dot (typed as the letter o with a period inside) denotes in matrix algebra a scalar product which is a correlation coefficient when the variables are in standard deviation units. The prime is often used already to specify or distinguish one particular entity.

C. Experimental comparison with statistical formulae. To test the relative parsimony of dimensional and current statistical notations, the 434 formulae in Dunlap and Kurtz' collection noted above were taken as a representative sample of the formulae of all the introductory statistical textbooks. An unexpected finding emerged. The S-system was not more parsimonious in writing a given statistical formula, since the two notations were in the main identical or equivalent. But the S-system reduced the number of different statistical formulae by the discovery of the master formula described above.[13]

A still more important contribution to parsiminious symbolism lies in the fact that the dimensional symbolism covers both the symbolisms of statistics and of logistics and of other fields as well. Thus, instead of learning different sets of operational symbols, it becomes possible for a student to learn but one set.

D. Comparison with current verbal concepts. The third comparison for parsimony is between dimensional and current verbal symbols. No new formal tests have been made since the large body of evidence that was presented in the *Dimensions of Society* volume. The list of 550 sociological concepts cited in Chapter XII and their reduction to S-formulae, as the sixteen S-symbols combined and varied, each over its range of possible values, constitute evidence as to whether S-notation is more or less parsimonious than prose or other verbal presentation.

IV. THE ISSUE OF POSTULATES

A. On the relation of the S-system to Lundberg's postulates. Mr. Calhoun, in closing his review, makes a comment in which both Mr. Lundberg and the author concur. Mr. Calhoun correctly remarks that the postulational basis presented in *Foundations of Sociology* and the particular system presented in *Dimensions of Society* do not necessarily stand or fall together. It may well be that the postulational basis will become woven into sociological thinking, while the S-system may be neglected or superseded by a better embodiment of those postulates. Nor does the S-system depend on all of Mr. Lundberg's postulates equally; it involves some more, others less. The S-system, however, depends on these postulates of natural science to a far larger extent than, conversely, those postulates depend upon the acceptance of any one application of them.

B. On records as the datum for sociological analysis. A fundamental postulate in the S-system is that all S-formulae require some form of *record* as their datum. An S-formula is not written from phenomena directly; it is only written according to explicit rules (See App. II) from a specified record of observed phenomena. The record may be in any form—prose, poetry, tabulation, graph, map, formula, movie film, rock carving, phonograph disc, or other form of symbols stored outside of the nervous system. A specific delimited record, i.e. "this paragraph in quotes," "this graph on p. 00," "Film A, reels 1 and 2," is the datum, the starting point for a dimensional analysis. Thus the formal statement of the S-system (pp. 26 and 58) says "Every quantitatively recorded situation can be expressed as. . . . " Everyone of the three hundred-odd S-situations which are reduced to formulae in *Dimensions of Society* presents the *recorded* data first and in the legend states that "the situation is a record of" or equivalent phrase.

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[13] A marked indirect parsimony was found, however, in that S-formulae could *say more* than statistical formulae could. Thus S-notation provides formulae for frequency distributions, correlation scattergrams and irregular aggregations of data as in a map or prose paragraph, for which statistics provides no notation. The scripts and qualifiers ${}^{s}_{s}(I^{\circ})^{s}_{s}$ in S-formulae could specify the conditions, limits, postulates, and nature of the variables in the formulae to a much greater degree than is possible in current statistical notation.

It may be noted in passing that, contrary to Mr. Calhoun's expectation, formulae in the theory of small samples were reducible to S-notation as parsimoniously as other statistical formulae. The definition of a fiducial limit which cannot be expressed in statistics without a paragraph of explanatory prose is statable in a simple S-formula in its standard notation and requires no further explanatory text.

Much misunderstanding has resulted from the failure of critics to grasp this postulate. They expect the S-system to tell them how to observe phenomena or even what phenomena to observe—a task which it explicitly disclaims.[14] Other considerations must guide the sociologist in converting phenomena to recorded observation. Only when they have been recorded does the S-system begin to apply. Just as a statistical formula or logical formula can only be applied when given recorded X's or classes or sentences, so the S-system only begins to apply when records are in hand. It guides the inductive and deductive manipulations, the analysis and synthesis in various operationally defined ways, of the recorded observations. The S-system is a second order of symbols—the first order being the records which scientists make of the phenomena they have observed. The second order of symbols is for treating the first-order symbols. Second-order symbols are for making summaries and conclusions, for defining concepts and stating relations, for interpreting and predicting, in short for helping to convert recorded observations into laws.

This breaking down of the scientific process into two stages—from phenomena to records of observation, and from records to verified generalizations—increases its objectivity and varifiability. The objectivity and verifiability of the second stage become measurable and high when using S-formulae since these include, and extend to qualities, the formulae of mathematics and logistics. Failure to verify generalizations can then increasingly be hunted down to errors in the first stage in proportion as the techniques of the second stage become more rigorous.

C. ON SOCIOLOGICAL LAWS AND PROBABILITY. The author agrees with one of Mr. Calhoun's postulates that sociological laws should more often be stated in terms of sociological probability. That sociological laws, or for that matter all empirically derived laws in any science, are matters of probability, to be expressed with probability or correlation coefficients ranging from zero to unity, seems to the author a basic postulate. Every equation between variables can be viewed as an implicit regression equation. The size of the correlation coefficient in this equation measures the degree of approximation to perfect equality between the two sides of the equation. For all exact equations, such as deductive or definitional equations, the correlation coefficient is implied and is unity. The regression equation, further, implies a standard error of sampling which measures the degree of probability of the observed correlation when interpreted by appropriate tables for small or large samples. When the correlation is unity, as in all exact equations, the standard error of estimate is zero and one side of the equation becomes a function of the other side with complete certainty.[15] Every equation in *Dimensions of Society* seems to the author to be intrinsically such a regression equation with its attendant probabilities which are mostly undetermined in the present state of sociology. Most of the equations there, however, being definitional equations in that they define an S, imply a correlation coefficient of unity and do not need to be written explicitly.

Towards carrying out the implications of this postulate, "indicators" are used in the S-system to replace the "characteristics" which they represent or indicate. An indicator, I, connotes that its limits and its reliability and its validity are determinable (pp. 157–62). Current names for characteristics in sociology do not ordinarily carry this connotation.[16]

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[14] See, for example, the complaint of T. Parsons (*American Sociological Review*, October 1942, p. 714) that *Dimensions* does not evaluate or otherwise deal with the theories of Marx, Weber, Durkheim, et al. This complaint seems to indicate a complete failure to grasp the nature of the undertaking represented by the *Dimensions*, although that undertaking appears to be stated with all possible explicitness in Chapter 1 and elsewhere. See the remarks of Read Bain on this subject in *Amer. Sociol. Rev.*, Feb. 1943. See also H. Ozanne in *Amer. Jour. of Sociol.* Mar. 1943.

[15] Fuller development of this postulate and some of its implications can be found in a paper by the author entitled "Induction, Deduction, and Causation" (*Sociometry*, VI: 119–148, 1943.) which is an operational redefinition in terms of correlation indices.

[16] Indirectly this distinction between indicator and its characteristics bears on Mr. Calhoun's question as to why "tension" was defined additively. "Tension" was not defined at all. An indicator, E, was defined (p. 265) as the ratio of the sum of the intensities of desire (in a plurel for a desideratum) divided by the available amount of that desideratum. Any other investigator is welcome to define other indicators multiplicatively or otherwise and try them out. Since no accepted indicator, usually called a criterion, of

D. On the taboo on borrowing from other sciences. Another postulate, namely, that it is invalid to use concepts in sociology similar to those in certain other sciences, seems to the author an unfortunate fetish. Just because borrowing from other sciences has sometimes been superficially or inappropriately done this should not blind scientists to the fact that an enormous amount of carry-over between sciences exists, especially in the concepts of methodology and mathematics, and that this carry-over greatly furthers the unity of all science. Carry-over based merely on analogy cannot be used for rigorous deduction. Some sociologists in the past (i.e. Herbert Spencer with his concept of society as an "organism") made the mistake of using conceptual analogies from other sciences for the making of deductions. The fallacies resulting from this reasoning-by-analogy led to a reaction against borrowing concepts from other sciences. Lacking operationally and rigorously defined concepts their reaction was justified. When, however, such rigorously defined concepts are available, as provided by the *S*-system, there is value in using common concepts.

Thus Mr. Calhoun condemns the tension equation as being "mechanistic-atomistic." Perhaps it is.[17] Does it matter for science whether an equation is "mechanistic-atomistic" or configurational or of other brand or school, so much as whether it contributes to improving societal prediction and control? This should be the single test in science of what is good methodology. It has mathematically demonstrable corollaries, such as: 1) any variable contributes to the prediction of a second variable (in the control of which men may be interested) in proportion to the correlation index between those two variables; and 2) such correlation will always be increased and never decreased by improving the reliability of each variable, since unreliability means errors which attenuate the correlation. The scientific test of concepts, hypotheses, or other sociological formulations, we submit, should increasingly turn on: what correlations do they yield? Then, questions of being either mechanistic or configurational become entirely secondary criteria, having force only in so far as it may be demonstrated in a given situation which of these secondary criteria contributes more to the scientific ends of prediction and control.

Because of this postulate, Mr. Calhoun criticizes the author's operational definitions of "effective social acceleration, momentum, and force," on the grounds of their being "taken over bodily from physics," and, to make the sin worse apparently, from classical physics.[18] Whether or not these

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tension seemed to exist, against which to correlate E and so to validate it, E remains simply a semi-operational definition of the concept E.

It was a methodological hypothesis that E thus defined will prove to be more reliable and to yield higher correlations with subsequent behavior of the group than the present verbal concept of "tension."

As to why the indicator, E, was defined as a ratio of *sums*, rather than as a ratio of products or other functions of the data, the answer is—simplicity, for a first approximation. An additive index is often based on Taylor's theorem, but the applicability of this theorem is here more a matter of faith than of proof. Also, since a true zero point is unknown for tensions and desires, a mean value usually has to be used as origin point. Then some of the variates may be zero-valued and in a continued product will spuriously wipe out the whole result—a difficulty that is not met in additive combining of the variates. In the last analysis, however, the correlations and subsequent predictions yielded by the proposed additive indicator compared with any other indicator must decide which is better.

[17] The author believes that the tension equation *when developed by its scripts* so that it describes any kinds and amounts of desire for any kinds and amounts of desiderata, whether qualitative, quantitative, or correlative in patterns, among single persons, plurels, or groups, in one or many periods or dates, becomes more in the nature of specifying patterns, or whole situations in society (See p. 273, 4). But this is secondary to the question of whether such complete formulation yields higher correlation indices with subsequent behavior in the population studied. These correlation indices test the degree of truth in our tension hypothesis, regardless of whether it is dubbed atomistic or configurational or otherwise.

[18] These definitions were (pp. 736, 578, 742):

Effective social acceleration = the speeding up of social change, measured by the amount of change twice divided by time,

$$A = I/T^2 \qquad \text{(Eq. 7a)}$$

Effective social momentum = a time rate of change of a characteristic in a population, measured by the amount of change, multiplied by the number of people changed, and divided by the time required to produce the change.

$$Mm = PI/T^2 \qquad \text{(Eq. 7b)}$$

Effective social force = the speeding up (or slowing down) of momentum, measured by the concepts tend to increase our ability to predict and control social phenomena Mr. Calhoun does not seem to consider. Yet the operational definitions in the footnote above were induced from an experiment in which progress in the hygienic culture complex of Syrian villages was being controlled and measured. These concepts measured exactly the degree of societal control achieved by the agency of a hygiene clinic in these communities. Later, in casting around for names for these concepts, as defined by the formulae in the footnote above, it was noted that similar operational formulae defined physical acceleration, momentum, and force. Hence, in the interest of unity of science these concepts were given the same names, *because defined by closely similar operational formulae.* Differences in content of the formula are distinguishable by adjectives which specify a "hygienic" force, an "educational" force, an "economic" force, or in general, a "social" force; just as physical forces may be an "electric" force, or a "thermal" force, or a "mechanical" force, etc. It is not useful to have a formula which, wherever the social change is measurable, can precisely and reliably measure any social force regardless of its origin or causal agency? Would not such exact measurement facilitate inter-correlating and predicting of forces? Might not such a precise definition of "an effective social force" clarify the policy of any periodical using the concept of "social force" in its title? (Since there are also *causative* social forces, which produce the changes measured in the formula for the resulting "effective social force" such a journal need not be limited to the field specified by the above formula (Eq. 7c)). Is it not useful to have a formula which unifies and enables one to interchange conceptually political forces, economic forces, religious forces, national forces, etc., just as by the formula for energy in physics the diverse phenomena for light and heat, mechanical motion and chemical action, electricity and magnetism, all become conceptually interchangeable?[19]

It may be noted in passing that the above formulae from Physical Mechanics are as true and useful today in their fields as they were fifty years ago before Einstein. Mr. Calhoun's epithet of "classical physics" vs. "modern physics" probably refers to recent theories in branches of physics other than mechanics. Perhaps he has in mind the field of quantum theory dealing with quanta of radiation in sub-atomic and inter-stellar fields which, by the way, are far more remote from social data than is the field of Physical Mechanics. It seems to be a fad today among some social scientists to ban mechanical theory and bless relativity theory. Perhaps this is because the sociologists, dealing usually with approximations and low probabilities among social data, seek specious support from Heisenberg's principle of indeterminacy. This principle applies only to a narrowly specialized area of physics, i.e. to observing extremely short radiations and electrons. It does not apply to Physical Mechanics, much less to sociology.

All this argument about valid and invalid borrowing from another field can be settled, we submit, by the sociological postulate: "Use *any* formulation for societal phenomena which measurably contributes to their prediction and control." Thereafter, the scientists' efforts are turned towards discovering and measuring the relative degree of such contributions between rival formulations of societal data.

E. On learning the rules for S-formulae. In conclusion, the author would like to make one suggestion to anyone wanting to use or appraise the S-system. It is that reading about the system is less adequate than manipulating it. To use or appraise it, reading statements about its symbolism or about the results of its analyses should be sup-

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positive or negative change of momentum per period,

$$F = Mm/T = PI/T^2 \qquad \text{(Eq. 7c)}$$

or, alternatively stated, a force is the celerating of change in a population, measured by the product of the celeration and the number of people celerated,

$$F = PA = PI/T^2 \qquad \text{(Eq. 7d)}$$

If mass, M, replaces the population, P, above and if the change, I, is in length or physical distance, the above formulae become those for physical acceleration, momentum, and force, respectively.

See Part IV of "A Controlled Experiment on Rural Hygiene in Syria," Dodd, S. C., American Univ. of Beirut, Social Science Series No. 7, 1934, pp. 336, for the original statement of these definitions and report of the experiment cited here.

[19] To interchange one force or one energy into another force or energy requires, of course, more than a unifying formula. Knowledge of the techniques for handling phenomena in each of these fields is also required. But the formula, when stated in comparable units, predicts their quantitative equivalences before converting one into another.

plemented by practice in writing S-formulae from sets of recorded data. One should actually analyze a sample of fifty or a hundred sets of recorded data, each set into its S-formula, and continue this practice until he achieves high reliability for his analyses, before he can expect to work creatively with this new tool. In testing the reliability of his analyses against another person's analyses, he will be firmly impressed with the absolute necessity of both analysts starting from some specified records in common if they wish to get the same statement in S-notation. Many of the differing interpretations by different sociologists can be eliminated by this prior agreement as to what record will represent the facts for both of them, and then by having a set of rules in common for drawing interpretations out of that common body of facts. The author starts his college juniors with two months of writing formulae from charts, tables, paragraphs or other records of sociological data. These students have had no previous course in sociology or in statistics. After two months they can begin to handle the symbolism with moderate reliability for simple situations and are then prepared to manipulate the system.

This practice in dimensional analysis is as necessary in sociology as is laboratory practice of qualitative and quantitative analysis in chemistry. The rules of analysis (App. II in *Dimensions of Society*) must first be mastered. If this practice is obtained, much misunderstanding and misuse of this new language for sociology may be avoided. For the S-system is largely a new scientific language, extending the languages of statistics and of symbolic logic, and there is no royal road to learning any language. The reward, however, is that the sociologist progresses a little along the road pointed up by Woodger in his statement: "If we have a perfect language we need not dispute. We need only to calculate and experiment." This expresses a basic postulate of the S-system. Sociologists today need such a language.